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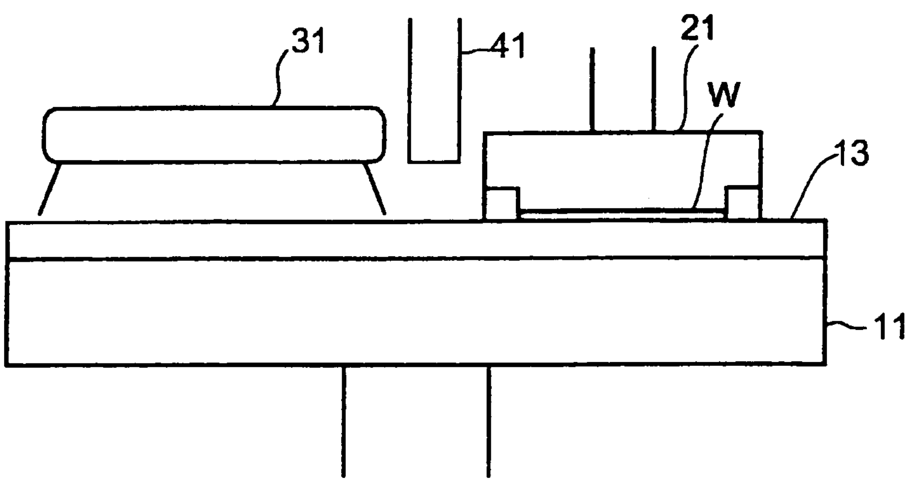

(57) Abstract: The apparatus for polishing a substrate while pressing the substrate into sliding contact with the fixed abrasive, comprises: a light source (32) for dressing the fixed abrasive by light irradiation; and a device (41) for supplying a chemical agent or a chemical liquid for promoting the self-generation of abrasive particles in the dressing by light irradiation. The supply of a chemical agent or a chemical liquid onto the surface of fixed abrasive can promote or maintain dressing effect attained by the light irradiation. The chemical agent or the chemical liquid to be supplied preferably contains boron, particularly preferably a borate.

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DESCRIPTION

POLISHING APPARATUS AND DRESSING METHOD

Technical Field

The present invention relates to an apparatus for polishing a substrate, such as a semiconductor wafer, with fixed abrasive for polishing, and particularly to a dressing method for dressing (regeneration) of the fixed abrasive.

Background Art

As semiconductor devices have recently become more highly integrated, circuit interconnections have become finer and the dimension of devices integrated has also become smaller. This often makes it necessary to provide the step of removing a film (a layer) formed on the surface of a semiconductor wafer by polishing to flatten the surface of the semiconductor. Polishing by means of a chemical mechanical polishing (CMP) apparatus is used as flattening means. This type of the chemical mechanical polishing (CMP) apparatus comprises a turn-table with a polishing cloth (pad) applied thereto and a top-ring. A substrate to be polished is interposed between the turn-table and the top-ring. In such a state that the substrate held by the top-ring is pressed under a given pressure against the polishing cloth (pad) applied to the turn-table, both the top-ring and the turn-table are rotated while supplying a polishing liquid (slurry) to the sliding surfaces of both the substrate and the polishing cloth, whereby the surface of the substrate is flattened and polished to provide a mirror-finish surface.

On the other hand, studies have been made on polishing of semiconductor wafers or the like by the so-

called "fixed abrasive" wherein abrasive particles, such as cerium oxide (CeO_2), have been fixed with a binder, for example, such as phenolic resin. In this polishing with fixed abrasive, unlike the polishing cloth used in the conventional chemical mechanical polishing, the abrasive material is hard. Therefore, in concaves and convexes, the convex portion is preferentially polished while the concave portion is less likely to be polished. This offers an advantage that absolute flatness can be easily realized. Further, for some composition of fixed abrasive, the so-called "self-stop function" appears wherein, as soon as polishing of the convex portion is completed to provide a flat surface, the polishing rate is remarkably lowered and, consequently, the polishing does not practically proceed. Further, in the polishing with fixed abrasive, since a polishing liquid (slurry) containing a large amount of abrasive particles is not used, the load applied to environment can be advantageously reduced.

In general, in the polishing with fixed abrasive, the surface of the fixed abrasive is regenerated (dressed) by means of a dresser with diamond particles or the like fixed thereto to self-generate free abrasive particles from the fixed abrasive. In polishing semiconductor wafers with fixed abrasive, the polishing rate immediately after the start of dressing is high. The polishing rate, however, is gradually lowered, and, thus, stable polishing rate cannot be realized. In order to stabilize the polishing rate, dressing should be carried out each time before polishing to satisfactorily self-generate free abrasive particles. In this case, however, since a given time is required for the dressing each time before polishing, the throughput is practically lowered and, consequently, the productivity is disadvantageously lowered.

The dresser with diamond particles used in chemical mechanical polishing involves a problem of the separation and falling of diamond particles onto the polishing surface. This sometimes causes scratching on the substrate in its surface to be polished.

Disclosure of Invention

The present invention has been made under these circumstances, and it is an object of the present invention to provide an apparatus for polishing a substrate with fixed abrasive, which does not involve the problem of the separation and falling of diamond particles onto a polishing surface. The apparatus and method for dressing enables free abrasive particles to be stably supplied to the polishing surface of the fixed abrasive, and thus can realize polishing at a stable polishing rate.

According to one aspect of the present invention, there is provided a method for dressing fixed abrasive for a substrate polishing process, which polishes a substrate while pressing the substrate into sliding contact with the fixed abrasive. The method for dressing comprises: irradiating light for dressing onto a surface of the fixed abrasive; and supplying a chemical agent or a chemical liquid onto the surface of the fixed abrasive to promote or maintain dressing effect attained by the light irradiation before or during dressing.

According to the present invention, upon light irradiation, the bond of the binder in the fixed abrasive is cleaved, and abrasive particles cannot be held in the fixed abrasive, resulting in the self-generation of abrasive particles. Since, however, portions cleaved by a photochemical reaction are likely to be re-bonded to each other, the abrasive particles are re-bonded to the binder,

leading to a problem that the amount of the abrasive particles self-generated is unstable. In order to overcome this problem, light is applied while supplying a certain chemical agent or chemical liquid to the fixed abrasive. In this case, re-bonding of cleaved binder portion can be prevented, and, in the dressing by light irradiation, the amount of the abrasive particles self-generated can be stabilized or increased.

The chemical agent or the chemical liquid to be supplied preferably contains boron, particularly preferably a borate. This constitution in combination with the light irradiation can realize the self-generation of a satisfactory amount of abrasive particles and thus can realize stable dressing.

The fixed abrasive comprises abrasive particles and a resin, and the resin is preferably an epoxy resin or an MBS resin. According to this constitution, in particular, the use of an MBS resin enables polishing utilizing properties of the MBS resin, which is soft from a microscopic viewpoint and is hard from a macroscopic viewpoint, to be stably performed based on the self-generation of a satisfactory amount of abrasive particles by the above dressing.

According to another aspect of the present invention, there is provided an apparatus for polishing a substrate while pressing the substrate into sliding contact with the fixed abrasive. The apparatus comprises: a light source for dressing the fixed abrasive by light irradiation; and a device for supplying a chemical agent or a chemical liquid for promoting the self-generation of abrasive particles in the dressing by the light irradiation. Here the chemical agent or the chemical liquid to be supplied preferably contains boron, particularly preferably a

borate.

Brief Description of Drawings

Fig. 1 is a diagram showing an apparatus for polishing a substrate according to an embodiment of the present invention wherein the apparatus is provided with fixed abrasive;

Fig. 2 is a diagram showing a variant of the embodiment of the polishing apparatus shown in Fig. 1, wherein a laser source is used as a light source;

Fig. 3 is a diagram showing a polishing apparatus provided with a device for removing polishing refuse after dressing;

Fig. 4 is a plan view showing the whole construction of a polishing apparatus provided with a photo-dresser;

Fig. 5 is a perspective view showing an embodiment of the construction of the photo-dresser; and

Fig. 6 is an elevational view showing an embodiment of the construction of the polishing apparatus.

Best Mode for Carrying Out the Invention

Preferred embodiments of the present invention will be explained in conjunction with the accompanying drawings.

Fig. 1 shows a polishing apparatus according to a first preferred embodiment of the present invention. Here in fixed abrasive 13, SiO_2, Al_2O_3, CeO_2 and the like may be used as abrasive particles, and resin materials, such as epoxy resins, phenolic resins, and polyimide resins, may be used as a binder. Since the above binder is an organic material, upon the application of light onto the polishing surface of the fixed abrasive, energy of the applied light cleaves the molecular bond and, consequently, abrasive particles are self-generated. The use of photo-reactive

fixed abrasive with TiO_2, ZnO or the like as a photocatalytic material mixed therein can further promote the self-generation of abrasive particles by lower-energy light. Both abrasive particles separated from the fixed abrasive and abrasive particles, which are in the state of being fixed onto the fixed abrasive but are exposed onto the surface of the fixed abrasive, are considered to participate in polishing. Dressing promotes the self-generation of abrasive particles having such both states thereof.

The polishing apparatus using the fixed abrasive 13 is provided with a light source 31, such as a mercury lamp or a low-pressure mercury lamp, and, as described above, the application of light from this light source 31 cleaves the bond of the binder material in the fixed abrasive to self-generate free abrasive particles. This polishing apparatus is provided with a chemical agent or a chemical liquid supply device 41. The supply of a suitable chemical liquid, when combined with light irradiation, can promote the self-generation of free abrasive particles and thus can promote or maintain dressing. Here the chemical agent or the chemical liquid to be supplied is preferably a boron-containing compound such as a borate.

The construction, wherein a top-ring 21 is provided for holding a substrate W to be polished and the substrate W to be polished is pressed against and, at the same time, is brought to sliding contact with the polishing surface of the fixed abrasive 13 to perform polishing, is the same as that of the above-described conventional polishing apparatus. The so-called "in-situ dressing" can be carried out wherein a semiconductor wafer W or the like is polished with the fixed abrasive 13 provided on the turn-table 11 being rotated while light is applied from the

light source 31 onto the fixed abrasive 13 to perform dressing.

Fig. 2 is a diagram showing a variant of the first embodiment shown in Fig. 1. In this apparatus, a laser source 33 is used as the light source, and a laser beam is applied to the fixed abrasive 13. The laser source 33 has a large number of laser beam emission ports which serve to apply the laser beams evenly to irradiation portion of the fixed abrasive 13. The laser source 33 is movable in a direction indicated by an arrow in the drawing. This can avoid local concentration of the laser beam, can apply a strong laser beam to give high energy density to the surface of the fixed abrasive 13, and can efficiently attain the effect of self-generating free abrasive particles that is dressing effect. Also in this embodiment, when a chemical agent or chemical liquid supply device 41 is provided and a boron-containing compound, such as a borate, is supplied by the device, the supply of the chemical agent or the chemical liquid in combination with light irradiation can realize good dressing.

In general, when a resin material is used as the binder, the resin material is a compound having C-H or C-C bond. When the end group (-H) or C-C bond on this surface is cleaved and a desired functional group is bonded to this spare bonding arm, abrasive particles are released on the surface of the fixed abrasive, that is, the self-generation of free abrasive particles can be promoted. Thus, dressing can be realized. That is, the same effect as in the case of dressing, for example, with a diamond tool can be attained. In general, the bond energy of C-H and the bond energy of C-C in the resin are 98 kcal/mol and 80.6 kcal/mol, respectively. Therefore, when light having a higher photon energy than this energy is applied

and, in addition, the light is absorbed in the exposed material to give a higher energy than the above bond energy, the molecular bond can be cleaved.

Light sources satisfying this requirement include KrF excimer laser beams of wavelength 248 nm and photon energy 114 kcal, ArF excimer laser beams of wavelength 193 nm and photon energy 147 kcal, and Xe excimer lamp beams of wavelength 172 nm and photon energy 162 kcal. These light sources have a narrow wavelength distribution and can apply high-energy light, but on the other hand, the cost is disadvantageously high. For this reason, a low-pressure mercury lamp may be used wherein lights with 253.7 nm and 184.9 nm, which are resonance lines of mercury, are strongly emitted although the wavelength distribution is broad. This can provide a low-cost light source for photo-dressing.

As described above, for example, the bond energy of the C-H bond in the resin molecule is 80.6 kcal/mol. Here, the energy necessary for self-generating free abrasive particles by cutting the bond is calculated as a test. Assuming that photon energy can be entirely absorbed on the exposed surface, the expression of relation between energy and wavelength

$$E = h/v$$

wherein h: Planck´s constant; and v: velocity,

shows that the application of light having a wavelength of not more than 351 nm can cleave the molecular bond.

In the dressing using photon energy, since the bond of the binder resin in the fixed abrasive is cleaved by a photochemical reaction, the binder no longer holds fixed abrasive particles and, thus, abrasive particles are self-generated. In this case, however, when the bonding arm of the binder resin cleaved by the photochemical reaction as

such is maintained, the bonding arm is re-bonded to the abrasive particles and, consequently, the abrasive particles are again fixed onto the binder. Therefore, the prevention of re-bonding between the binder and the abrasive particles, which have been cleaved by the photochemical reaction, is important, and this can stabilize or increase the amount of free abrasive particles self-generated. Experiments conducted by the present inventors have revealed that, when epoxy resin or MBS resin is used as a binder for the fixed abrasive particles, the application of ultraviolet light while supplying an ionic aqueous sodium borate solution as a borate which is a boron-containing compound, can offer significant dressing effect. This chemical liquid is generally known as a standard buffer solution (a borate pH standard solution), pH = 9.18 (25°C).

The results of an experiment, wherein this chemical liquid has been supplied in photo-dressing of fixed abrasive using an epoxy resin as the binder, are shown in Table 1.

Table 1

Test No.	Supplied chemical liquid	Light irradiation	1st semiconductor wafer [angstrom/min]	2nd semiconductor wafer [angstrom/min]	3rd semiconductor wafer [angstrom/min]
1	Pure water alone	Done	26	3	12
2	Pure water alone	Not done	27	5	3
3	Alkaline solution (KOH, pH = 10.6)	Done	27	6	18
4	Alkaline solution (KOH, pH = 10.6)	Not done	32	6	8
5	Standard buffer solution (borate pH standard solution)	Done	27	3	94
6	Standard buffer solution (borate pH standard solution)	Not done	28	5	21

In the above experiment, cerium oxide particles were used as the abrasive particles, an epoxy resin was used as the binder, and a low-pressure mercury lamp was used as the light source. In the experiment, the polishing surface of the fixed abrasive was first dressed with a diamond dresser. The first semiconductor wafer was then polished for 10 min, and, without interruption, that is, without dressing of the polishing surface, the second semiconductor wafer was then polished for 10 min. Thereafter, in one case, after the application of ultraviolet light for 30 min while supplying the chemical liquid to the polishing surface of the fixed abrasive, and,

in another case, after standing for 30 min without the application of ultraviolet light, the third semiconductor wafer was polished. In this case, three chemical liquids of pure water, an alkaline (KOH) solution, and a standard buffer solution (a borate pH standard solution, pH = 9.18 (25°C)) were used. The polishing rate of the semiconductor wafers for individual combinations of the above conditions is shown in Table 1.

Specifically, in test Nos. 1 and 2, pure water alone was used as the chemical liquid to be supplied. Test Nos. 1 and 2 are different from each other in that light irradiation was carried out in test No. 1 while light irradiation was not carried out in test No. 2. The results show that, in polishing immediately after dressing with the diamond tool, the polishing rate was 26 to 27 angstrom/min for each test and, in subsequent polishing of the second semiconductor wafer, the polishing rate was significantly lowered to 3 to 5 angstrom/min for each test, and, in particular, in polishing of the second semiconductor wafer, the amount of free abrasive particles self-generated was very small. Also in polishing of the third semiconductor wafer, when light irradiation was carried out while supplying pure water, the polishing rate was somewhat increased to 12 angstrom/min. This polishing rate, however, is a very low value. In the polishing of the third semiconductor wafer, when polishing was carried out without light irradiation, the polishing rate was about 3 angstrom/min and the effect of increasing the amount of the self-generated abrasive particles by the dressing could not be attained at all.

Next, in test Nos. 3 and 4, before polishing of the third semiconductor wafer, light irradiation was carried out while supplying the alkaline solution (test No. 3), or

light irradiation was not carried out while supplying the alkaline solution (test No. 4). The wafer polishing rates in the polishing of the first and second semiconductor wafers were the same as described above. In dressing before polishing of the third semiconductor wafer, when light irradiation was carried out while supplying the alkaline solution, the polishing rate was somewhat increased and was 18 angstrom/min, whereas, when light irradiation was not carried out while supplying the alkaline solution, the polishing rate was 8 angstrom/min, indicating that free abrasive particles were not substantially self-generated, that is, the effect of dressing was not substantially attained.

In test Nos. 5 and 6, a borate pH standard solution was used as the chemical liquid to be supplied. Also in this case, light irradiation was carried out while supplying the borate pH standard solution (test No. 5), or light irradiation was not carried out while supplying the borate pH standard solution (test No. 6). The results of polishing of the first and second semiconductor wafers are the same as described above. Regarding the results of polishing of the third semiconductor wafer, it should be noted that, for test No. 5 wherein light irradiation was carried out, a high polishing rate of 94 angstrom/min was provided. The reason why this high polishing rate could be provided is believed to reside in that, by virtue of the combination of the standard buffer solution with the light irradiation, the bond of the resin was cleaved upon light irradiation, and the cleaved portion of the bond is terminated by the influence of the standard buffer solution to surely self-generate free abrasive particles. Also in the case where light irradiation was not carried out, the use of the borate pH standard solution provided a

good polishing rate of 21 angstrom/min which was larger than that provided in test Nos. 1 to 4.

The above results show that light irradiation while supplying the borate pH standard solution can significantly increase the amount of self-generated free abrasive particles and can provide good results of dressing. When an alkaline solution was supplied as the chemical liquid, the polishing rate was somewhat improved, probably because the alkaline solution absorbed in the fixed abrasive influenced the polishing. Likewise, in the case where the standard buffer solution (borate pH standard solution, pH = 9.18 (25°C)) was used and light irradiation was not carried out, the polishing rate was improved. This improvement is considered attributable to the fact that the effect attained by the supply of the standard buffer solution (borate pH standard solution) is higher than the effect attained by the alkaline solution.

Next, a polishing tool with fixed abrasive using methyl methacrylate butadiene styrene (MBS) resin will be described. The MBS resin is a copolymer produced using methyl methacrylate, butadiene, and styrene as main starting materials. This copolymer is mainly used as a modifier for improving the impact resistance of vinyl chloride resin or acrylic resin. For polishing tools with fixed abrasive using an MBS-containing vinyl chloride or acrylic resin as a binder, in general, the amount of the MBS resin added is approximately several % to 20%. This is a design in which importance is attached to the properties of vinyl chloride. On the other hand, when the proportion of the MBS resin in the resin is increased to not less than 20%, to not less than 50%, or to 100%, a tool having high impact absorption effect is provided.

In addition to MBS, for example, resins with

elastomers (EPR, butadiene rubber, ethylene-propylene rubber or the like) dispersed therein, and core-shell-type resins using an elastomer as the core have the same effect as described above. For example, PP block polymer (impact copolymer), PMMA, TPE, HIPS, ABS, AES, SBS, SEBS, SEPS, EVA, CPE, MBS, PET, PBT, and TPU either as such or as additives can be expected to have the same effect as described above.

When this resin is used as a binder in combination with ceria abrasive particles, a polishing tool with fixed abrasive can be provided which scratch is much less likely to occur at the time of polishing. For example, a mixture of an epoxy resin with an MBS resin may be used as the binder. Specifically, in this polishing tool with fixed abrasive, since the MBS resin used is a thermoplastic resin, the mold-ability is good and, in addition, the strength of the molded product is high. Further, when the MBS resin is used as the binder, the self-generation of abrasive particles can be provided and thus can realize high polishing rate. For example, the polishing rate is about twice higher than that of the conventional polishing tool with fixed abrasive using an epoxy resin as the binder. Further, since the resin per se has impact resistance, the force applied to the abrasive particles at the time of polishing is relaxed (suppressed). By virtue of this, scratch-free, that is, substantially defect-free polishing can be realized. It is considered that, in MBS resin-bonded fixed abrasive, the structure is widened by water absorption effect and the capability of holding the abrasive particles is lowered to make it easy to self-generate abrasive particles.

As described above, this polishing tool with fixed abrasive is advantageous over the conventional polishing

tool with phenolic or epoxy resin-bonded fixed abrasive in that the polishing rate is high and scratch is less likely to occur. That is, this polishing tool with fixed abrasive can also be applied to a semiconductor production process in which the occurrence of scratches is unfavorable. Further, in a process which requires a high polishing rate such that the conventional polishing tool with phenolic or epoxy resin-bonded fixed abrasive requires dressing during polishing, a necessary high polishing rate can be provided without dressing during polishing. Furthermore, since there is no fear of causing the separation of diamond abrasive particles during dressing, scratching by diamond particles does not occur.

Table 2 shows the results of an experiment on dressing of fixed abrasive using an MBS resin as the binder. The other experimental conditions are the same as described above. Specifically, cerium oxide particles were used as the abrasive particles, an MBS resin was used as the binder, and a low-pressure mercury lamp was used as the light source. Regarding polishing conditions, for the first semiconductor wafer, polishing was carried out after dressing by a diamond tool; and for the second semiconductor wafer, polishing was carried out subsequent to the polishing of the first semiconductor wafer. After the polishing of the second semiconductor wafer, dressing was then carried out while supplying a chemical liquid in combination with light irradiation in one case and without light irradiation in another case, and the third semiconductor wafer was then polished.

Table 2

Test No.	Supplied chemical liquid	Light irradiation	1st semiconductor wafer [angstrom/min]	2nd semiconductor wafer [angstrom/min]	3rd semiconductor wafer [angstrom/min]
1	Pure water alone	Done	119.2	102.2	102.5
2	Pure water alone	Not done	119.2	101.8	93.7
3	Standard buffer solution (borate pH standard solution)	Done	126.0	100.8	117.8

The results of the comparison of polishing rates shown in Table 2 are as follows. In test Nos. 1 and 2, only pure water was used as the chemical liquid to be supplied, and a comparison of polishing rate was made between the case where light irradiation was carried out and the case where light irradiation was not carried out. As shown in Table 2, there was no significant difference in polishing rate among the first semiconductor wafer, the second semiconductor wafer, and the third semiconductor wafer. In the case of fixed abrasive using the MBS resin as the binder, as described above, the degree of lowering in polishing rate by continuous polishing is smaller than that in the case of fixed abrasive using the epoxy resin as the binder. In the case where pure water was supplied as the chemical liquid and light irradiation was not carried out, there is a tendency that the polishing rate is gradually lowered. In the case where light irradiation was carried out, however, the polishing rate was not lowered and was stable. When the standard buffer solution (a borate pH standard solution, pH = 9.18 (25°C)) was supplied as the chemical liquid while applying light, the

polishing rate was improved to the level of the initial polishing rate. Specifically, also in the case of the fixed abrasive using the MBS resin, photo-dressing in combination with a borate solution can realize a polishing rate close to dressing by means of a diamond dresser.

In dressing of the fixed abrasive, the supply of an oxidizing agent having an oxidative decomposition activity to a polymeric resin as the binder for fixing the abrasive particles is also effective. Oxidizing agents usable herein include: aqueous ozone; aqueous hydrogen peroxide; organic peroxides, such as peracetic acid, perbenzoic acid, and tert-butyl hydroperoxide; permanganic acid compounds, such as potassium permanganate; bichromic acid compounds, such as potassium bichromate; halogenic acid compounds, such as potassium iodate; nitric acid compounds, such as nitric acid and iron nitrate; perhalogenic acid compounds, such as perchloric acid; transition metal salts, such as potassium ferricyanide; persulfates, such as ammonium persulfate; and heteropoly-acid salts. Among them, aqueous hydrogen peroxide and organic peroxides, which are free from any metal element and of which the decomposition product is harmless, are preferred from the practical point of view.

The above peroxides are unstable and thus generate radicals, and unpaired electrons thereof easily oxidize the binder resin. The aqueous hydrogen peroxide is decomposed upon exposure to ultraviolet light to generate hydroxy radicals. The bond dissociation energy of H-OH in this hydroxy radical is about 120 kcal/mol, which is larger than the bond dissociation energy of R-H in all the resins. Therefore, R-H in the binder resin is converted to R radicals by hydroxy radicals. The generated R radicals further react, for example, with hydroxy radicals to cause

oxidative decomposition. Preferably, the concentration of hydrogen peroxide is 0.001 to 60% by weight, the pH value is 1 to 14, more preferably 8 to 10, and the wavelength of the ultraviolet light is not more than 450 nm.

These oxidizing agents having an oxidative decomposition activity oxidize and deteriorate the polymeric resin as the binder, cause cleavage of the main chain, decomposition, and a reduction in molecular weight to mechanically weaken the surface layer of the fixed abrasive, and remove the surface layer to promote the self-generation of abrasive particles. The application of the above light in dressing using the oxidizing agent having an oxidative decomposition activity can provide synergistic effect in photo-dressing for promoting the self-generation of abrasive particles from the fixed abrasive. Further, even when light is not applied, the supply of an oxidizing agent having an oxidative decomposition activity onto the surface of the fixed abrasive can promote dressing of the surface layer of the fixed abrasive by the above function.

Further, the incorporation of a photo-initiator (a photo-sensitizer) into the fixed abrasive or the incorporation of a photo-initiator (a photo-sensitizer) into a chemical agent or a chemical liquid supplied to the fixed abrasive during dressing is also useful for the photo-dressing. In these states, upon the application of light, such as ultraviolet light, onto the surface of the fixed abrasive, the photo-initiator (photo-sensitizer) absorbs ultraviolet light and generates radicals or ions by cleavage or hydrogen abstraction, and the surface layer of the binder resin constituting the fixed abrasive is decomposed to promote the self-generation of abrasive particles. Photo-initiators (photo-sensitizers) include

acetophenone, diacetyl, 2,2´-azobisisobutyronitrile, anthraquinone, iron chloride, 1,1-diphenyl-2-picrylhydrazine (DPPH), iron dimethylcarbamate, thioxanthone, tetramethylthiuram sulfide, 1,4-naphthoquinone, p-nitroaniline, phenanthrene, benzil, 1,2-benzoanthraquinone, p-benzoquinone, benzophenone, Michler's ketone, 2-methylanthraquinone, and 2-methyl-1,4-naphthoquinone (vitamin K3). The concentration of the photo-initiator (photo-sensitizer) in the fixed abrasive is preferably about 0.05 to 10%, more preferably about 0.1 to 5%. An example of effective excitation wavelength of ultraviolet light compatible with the photo-initiator (photo-sensitizer) is about 257 nm for thioxanthone and is 251 nm for 1,4-naphthoquinone.

In order to promote photo-dressing, preferably, a part or the whole of the resin constituting the binder of the fixed abrasive is accounted for by a photo-sensitive resin, and a solution, which can dissolve the resin after exposure, is supplied as the chemical agent or the chemical liquid to be supplied during dressing. In the photo-sensitive resin, particularly a positive-working photo-sensitive resin which, upon exposure to light, causes a reaction to change properties, when the photo-sensitive resin is subjected to denaturation or decomposition/depolymerization in its portion exposed to light during dressing, the resin becomes more dissolvable in a solution, which can dissolve the resin after exposure, such as an organic solvent, an aqueous alkaline solution, or pure water. Therefore, when a positive-working photo-sensitive resin and abrasive particles and, if necessary, other binder resin are mixed together to form fixed abrasive, the application of light, such as ultraviolet light, and, further, bringing a solution capable of

dissolving the resin after exposure into contact with the surface of the fixed abrasive can realize the dissolution of the positive-working photo-sensitive resin together with other binder resin to promote the self-generation of abrasive particles. The organic solvent used as a solution, which can dissolve the resin after exposure, is selected according to dissolution properties of the photo-sensitive resin after exposure. When an aqueous alkaline or acidic solution is used, the dissolution can be promoted by a neutralization reaction between the acid and the alkali.

When the positive-working photo-sensitive resin is, for example, photo-disintegrative PMMA (polymethyl methacrylate) or PMIPK (polymethyl isopropenyl ketone), a reduction in molecular weight occurs upon exposure to light. In this case, after exposure, a mixed liquid composed of organic solvents, for example, methyl isobutyl ketone and isopropyl alcohol can dissolve the resin subjected to molecular weight reduction. When dissolution inhibition-type novolak resin and o-diazonaphthoquinone compound are used, upon exposure to light, indenecarboxylic acid occurs and is dissolved in the alkaline solution. When polyvinyl alcohol as a water-soluble resin is mixed with a photo-sensitive composition, water may be used as a solution which can dissolve the resin after exposure. The resin usable as the positive-working photo-sensitive resin is preferably $(CH_2\text{-}CR1R2)_n$- wherein R1 represents CH_3 and R2 represents H, $-CH_3$, -COOH, $-COOCH_3$, $-COOC_2H_5$, $-COOC_3H_7$, $-COOC_4H_9$, $-COOC_5H_{11}$, $-COOCH_2CF_2CHF\text{-}CF_3$, $-C_6H_5$, $-CONH_2$, CN, $-COCH_3$, or a copolymer thereof.

When a photo-sensitive resin is incorporated into the fixed abrasive to promote photo-dressing, preferably, if possible, for example, antioxidants, ultraviolet absorbers,

photo-stabilizers, radical inhibitors, metal inactivators, and peroxide decomposers contained in resins as conventional binders are not added.

In some cases, the surface layer of the fixed abrasive is shaved by dressing, and the resultant refuse stays on the surface of the fixed abrasive. In this case, a method is preferably adopted wherein a liquid is ejected onto the fixed abrasive to remove the refuse by the liquid pressure or a gas is blown against the fixed abrasive to remove the refuse by the gas pressure. In this case, as shown in Fig. 3, polishing refuse of the fixed abrasive may be removed by an atomizer 32 which ejects, for example, nitrogen gas and pure water in the form of mist. Polishing refuse of the fixed abrasive produced by dressing may be swept out, for example, with a nylon brush. Alternatively, non-contact removing means, which does not directly contact the surface of the fixed abrasive, for example, plasma irradiation or ultrasonic vibration, may be used for the removal of the refuse.

Fig. 4 is an embodiment showing the construction of a polishing apparatus equipped with a dresser using light irradiation and supply of a chemical liquid according to the present invention. In this apparatus, first and second polishing units 51a, 51b are disposed as left and right polishing units so as to face each other on one end side of a space on a floor of which the whole shape is rectangular. A pair of load and unload units for mounting thereon semiconductor wafer housing cassettes 52a, 52b are disposed on the other end side. Two transfer robots 54a, 54b are disposed on a transfer line connecting the polishing units to the load and unload units. Reversing devices 55, 56 are disposed on both respective sides of the transfer line, that is, the reversing device 55 is

disposed on one side of the transfer line while the reversing device 56 is disposed on the other side of the transfer line. Two cleaning devices are disposed on each side of the transfer line. That is, cleaning devices 57a, 58a are disposed on both respective sides of the reversing device 55, and cleaning devices 57b, 58b are disposed on both respective sides of the reversing device 56. A push 66 for temporarily mounting thereon a substrate to be polished is disposed near the transfer robot 54b.

The first and second polishing units 51a, 51b each comprise: a turn-table 24 having a polishing tool (fixed abrasive) mounted on its upper surface; a top-ring mechanism 60 which holds, by vacuum sticking, a semiconductor wafer as an object to be polished and presses the semiconductor wafer against the surface of the turn-table; a dresser mechanism 61, such as a conventional diamond dresser, for dressing fixed abrasive; and a dresser mechanism 62 using the above light irradiation and the supply of a chemical liquid. The two polishing units, equipped with the turn-table, the top-ring mechanism, and the dresser mechanism, basically having the same specifications are disposed symmetrically with respect to the transfer line.

Fig. 5 shows an embodiment of the whole construction of a photo-dressing mechanism. A photo-dresser unit 75 equipped with a light source lamp 63, a chemical liquid supply nozzle 67 and the like is connected to and fixed to a drive arm 77 through a vertically movable cylinder 76. The photo-dresser unit 75 is vertically moved by the vertically movable cylinder 76 to regulate the spacing between the light source lamp 63 and the polishing surface of the fixed abrasive to be dressed. The drive arm 77 is moved within a horizontal plane to position the polishing

surface of the fixed abrasive to be dressed.

Fig. 6 shows an embodiment of the construction of the polishing unit. The turn-table 11 is provided with a polishing tool (fixed abrasive) 13. A wafer, to be polished, held by the top-ring 21 is pressed against the surface of the fixed abrasive by the top-ring mechanism 60 and, in this state, is rotated and brought into sliding contact with the fixed abrasive, whereby polishing proceeds. The polishing unit comprises a dressing mechanism 61, which is provided with a conventional diamond dresser 19 and utilizes mechanical contact, and a dressing mechanism 62 equipped with a light source 63, such as a mercury lamp, and a chemical liquid supply nozzle 67, for dressing the polishing surface of the fixed abrasive. Here dressing is usually carried out by the dressing mechanism using light irradiation before or during polishing of the wafer. The conventional dressing mechanism 61 is used for removing large concaves and convexes formed on the fixed abrasive surface to flatten the whole polishing surface. In general, this conventional dressing is carried out according to need after polishing of a plurality of wafers. Further, a method may be adopted wherein the surface of the fixed abrasive is monitored with a fixed abrasive surface measuring device and, for example, when the level of concaves and convexes has reached not less than 1 μm, dressing utilizing the mechanical contact is carried out.

As described above, according to the present invention, for polishing using the fixed abrasive, a combination of light irradiation with the supply of a chemical liquid can realize efficient and stable dressing without causing scratching or other unfavorable phenomena. Also, it should be noted that the present invention can be

used in both in-situ polishing process (dressing while polishing is conducted) and ex-situ polishing process (dressing while polishing is not conducted).

Industrial Applicability

The present invention is applicable to an apparatus for polishing a substrate, such as a semiconductor wafer, with fixed abrasive for polishing. Thus, the present invention is applicable for manufacturing semiconductor devices, liquid crystal devices, and so on.

CLAIMS

1. A method for dressing fixed abrasive for a substrate polishing process, which polishes a substrate while pressing the substrate into sliding contact with the fixed abrasive, said method for dressing comprising:

irradiating light for dressing onto a surface of the fixed abrasive; and

supplying a chemical agent or a chemical liquid onto the surface of the fixed abrasive to promote or maintain dressing effect attained by the light irradiation before or during dressing.

2. A method for dressing fixed abrasive according to claim 1, wherein the chemical agent or the chemical liquid contains boron.

3. A method for dressing fixed abrasive according to claim 1, wherein the chemical agent or the chemical liquid contains a borate.

4. A method for dressing fixed abrasive according to claim 1, wherein the fixed abrasive comprises abrasive particles and a resin, and the resin is an epoxy resin or an MBS resin.

5. A method for dressing fixed abrasive according to claim 1, wherein the chemical agent or the chemical liquid contains an oxidizing agent having an oxidative decomposition activity.

6. A method for dressing fixed abrasive according to claim 1, wherein the fixed abrasive contains a photo-initiator.

7. A method for dressing fixed abrasive according to claim 1, wherein the chemical agent or the chemical liquid contains a photo-initiator.

8. A method for dressing fixed abrasive according to claim 1, wherein the fixed abrasive contains a photo-sensitive resin and the chemical agent or the chemical liquid is a liquid which can dissolve the resin after exposure of light irradiation.

9. A method for dressing fixed abrasive for a substrate polishing process, which polishes a substrate while pressing the substrate into sliding contact with the fixed abrasive, said method for dressing comprising:

supplying an oxidizing agent having an oxidative decomposition activity onto the surface of the fixed abrasive to promote or maintain dressing effect before or during dressing.

10. An apparatus for polishing a substrate while pressing the substrate into sliding contact with fixed abrasive, said apparatus comprising:

a light source for dressing the fixed abrasive by light irradiation; and

a device for supplying a chemical agent or a chemical liquid for promoting self-generation of abrasive particles in the dressing by the light irradiation.

11. A polishing apparatus for a substrate according to claim 10, wherein the chemical agent or the chemical liquid supplied contains boron.

12. A polishing apparatus for a substrate according to claim 10, wherein the chemical agent or the chemical liquid contains a borate.

13. A polishing apparatus for a substrate according to claim 10, wherein the chemical agent or the chemical liquid contains an oxidizing agent having an oxidative decomposition activity.

14. A polishing apparatus for a substrate according to claim 10, wherein the chemical agent or the chemical liquid contains a photo-initiator.

15. A polishing apparatus for a substrate according to claim 10, wherein the fixed abrasive contains abrasive particles and a resin, and the resin is an epoxy resin or an MBS resin.

16. A polishing apparatus for a substrate according to claim 10, wherein the fixed abrasive contain a photo-sensitive resin, and the chemical agent or the chemical liquid is a liquid which can dissolve the resin after exposure of light irradiation.

FIG. 1

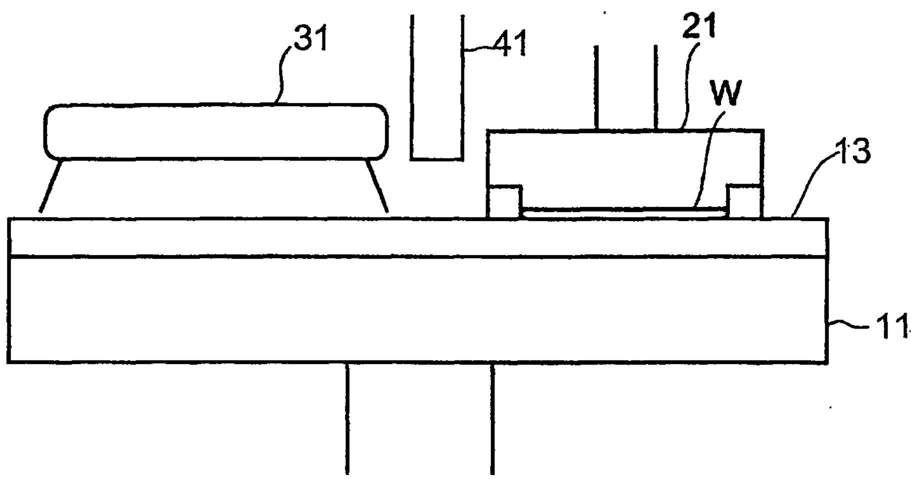
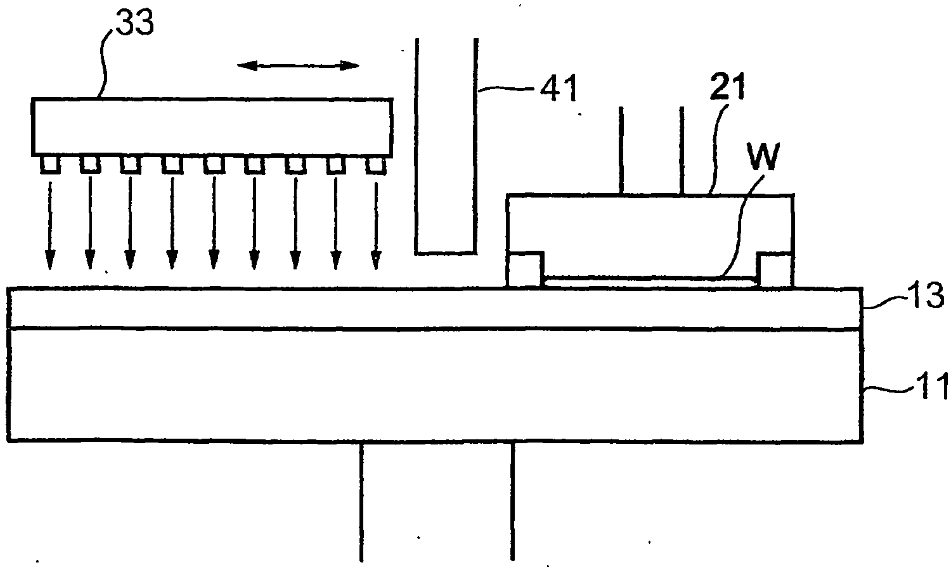
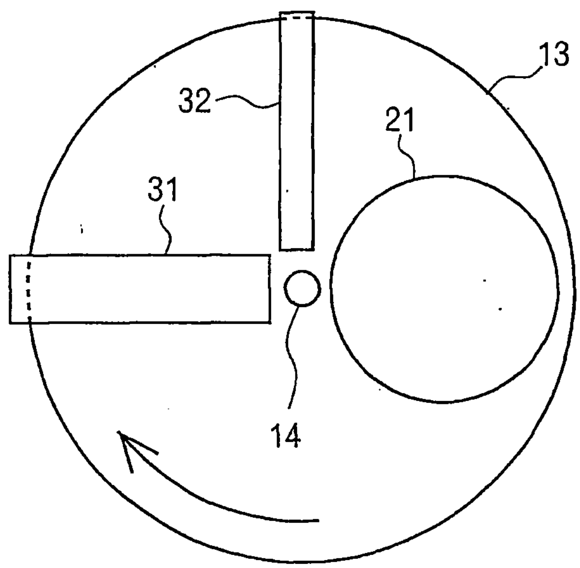


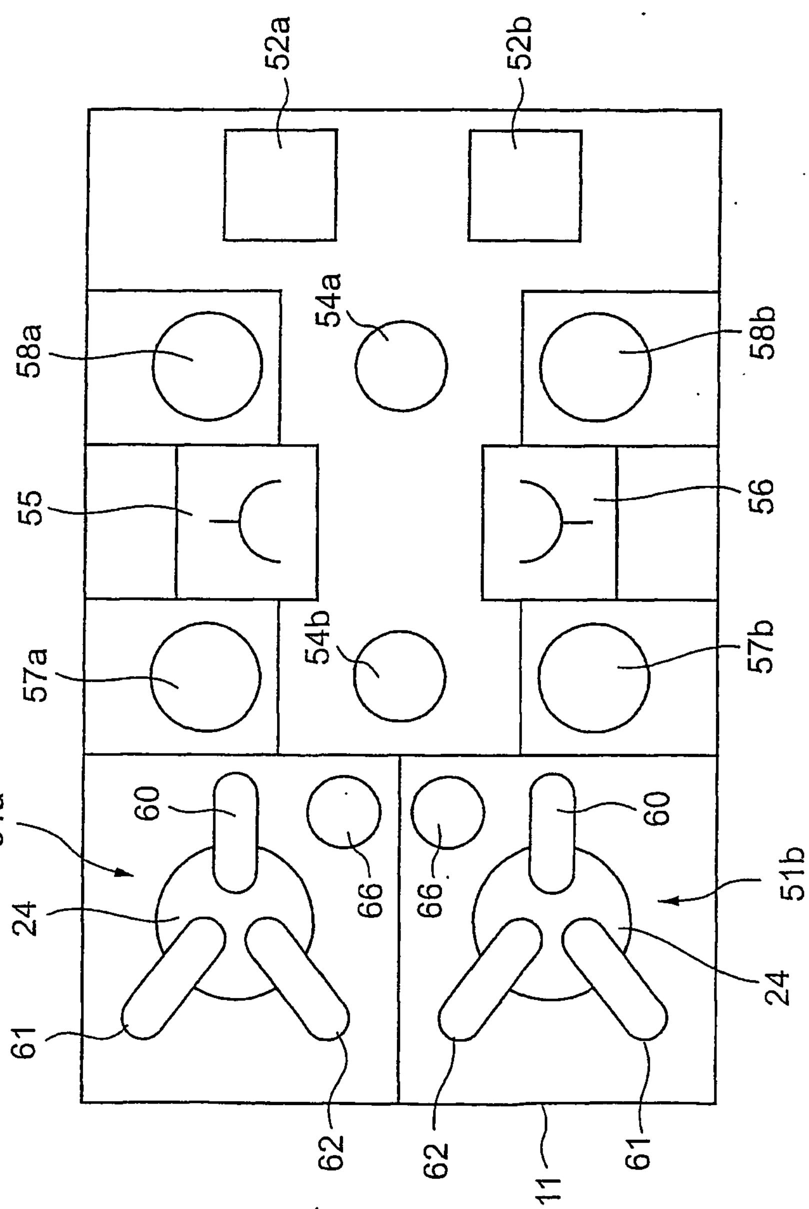
FIG. 2



F I G. 3



F I G. 4


52a
52b
58a
54a
58b
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56
57a
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51a
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51b
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24
61
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11
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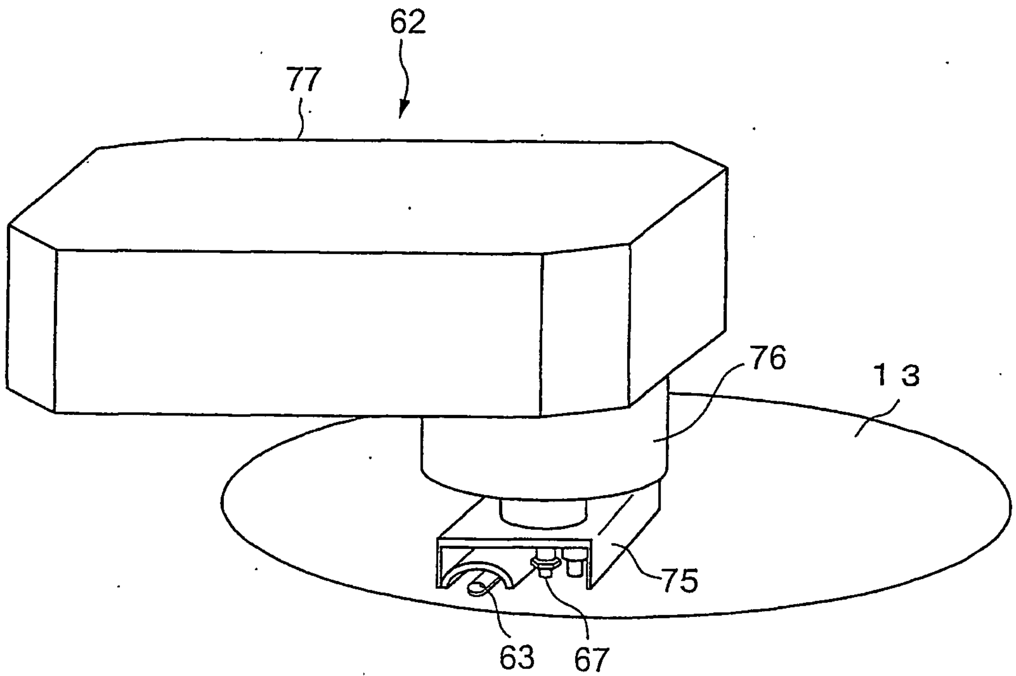
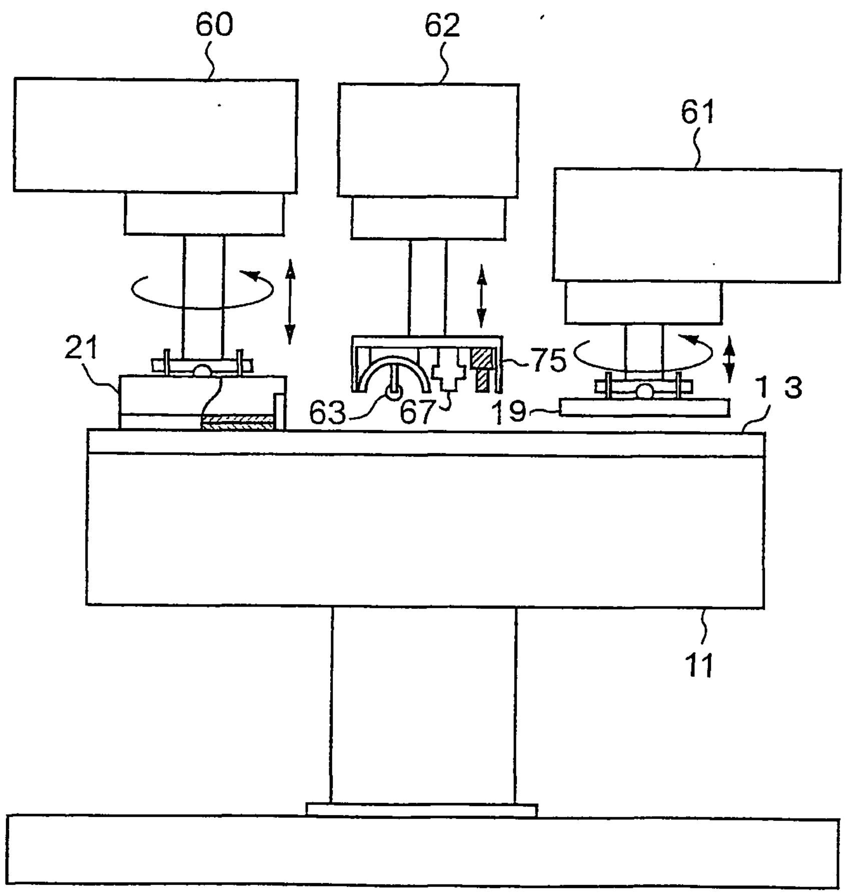
FIG. 5



F I G. 6



INTERNATIONAL SEARCH REPORT

Int nal Application No
PCT/JP 02/01456

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B24B37/04 B24B53/007

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B24B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 June 2002	25/06/2002

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Schultz, T

INTERNATIONAL SEARCH REPORT

In nal Application No
PCT/JP 02/01456

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